NASA TECH BRIEF

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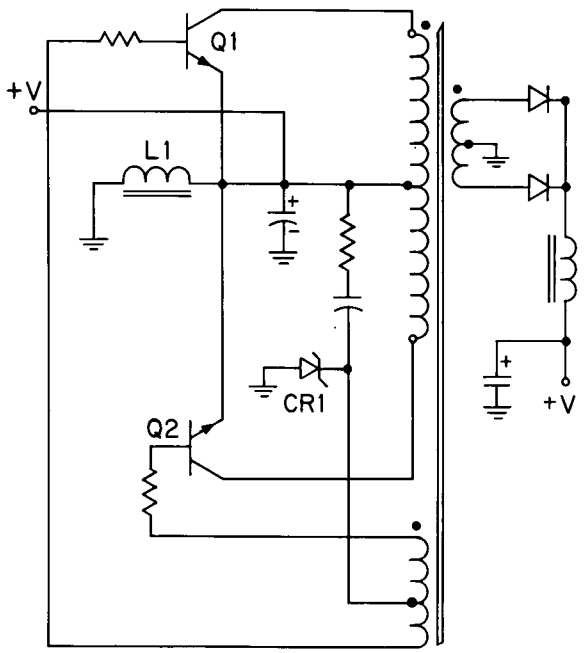
Pseudo-Saturating Power Converter

A study has been made of the relative performance of three basic configurations of electronic conversion units for space applications requiring low power levels (0–3 W). The conversion units are DC-to-DC power devices in which the critical component is the transformer and the parameter under study was the degree of saturation of its core.

Depending on the extent to which the B-H loop of the transformer is utilized, an electronic converter unit is classified as saturating, pseudo-saturating, or nonsaturating. The saturating mode of operation signifies that the entire B-H loop is involved and, moreover, the transformer is driven so far into saturation that H_{sat} is several orders of magnitude greater than H_{mag}. When operated in pseudo-saturation, almost the entire B-H loop is used; the electronic conversion unit cuts off power supplied to the transformer as soon as saturation is imminent. In a nonsaturating mode of operation, only a small portion of the B-H loop is utilized.

A typical circuit for the pseudo-saturating conversion unit is shown in the diagram. Inductor L1 and Zener diode CR1 prevent the transformer from going deeply into saturation. When the transformer core (a high-permeability material) begins to saturate, current flow increases rapidly in inductor L1; this increases the voltage level at the emitters of Q1 and Q2. Because of base-emitter capacitances, the bases of Q2 and Q1 will follow the emitter until the base voltages are clamped by the Zener diode CR1; the transistors then turn off and limit the current flow into the primary of transformer T1.

The base current that is fed back to the transistors by the feedback winding can be decreased to the point where the unit will stop functioning. In making comparisons of the various configurations (with the same transformer and no secondary loads), the lower the cutoff current level, the better the regeneration; the pseudo-saturating configuration was found to



have an excellent regeneration figure and superior to the saturating configuration; the nonsaturating configuration was rated poor.

The power conversion efficiency of the pseudo- and nonsaturating units were comparable over a power output range of 0 to 3.5 watts; in contrast, the saturating converter showed poor efficiencies because of large losses from current spiking.

The least amount of current spiking was observed in the unit operating in the nonsaturating mode at

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low power levels; however, at higher power levels current spikes were formed. In contrast, current spikes were high at all power levels in units operating at saturation. The spiking level in the pseudo-saturation mode of operation were found much lower than at saturation; the reduced spikes are attributable to the effect of L1 and CR1 on current flows.

Another parameter of performance that was investigated relates to the amount of output filtering that is required and the amount of current modulation reflected on the input power line. The parameter is called the crossover period, and it is defined as the period during which the converter unit does not deliver energy to the transformer secondary; no power is delivered when the unit switches. The saturating mode of operation has the worst crossover characteristics because transistor switching speeds are deliberately made slow in order to prevent excessively large current spikes in the primary. The nonsaturating mode of operation provides the best crossover characteristics. The crossover gap in the pseudo-saturating mode of operation increases considerably with load because of the decrease of inductance caused by DC current flow in L1. However, the crossover gap is quite acceptable.

The pseudo-saturating mode exhibits the best overall performance, the nonsaturating a close second, the saturating a poor third.

Note:

Requests for further information may be directed to:

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No patent action is contemplated by NASA.

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